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TECHNICAL MANUAL

OPERATOR AND ORGANIZATIONAL
MAINTENANCE MANUAL INCLUDING
REPAIR PARTS AND SPECIAL
TOOL LISTS

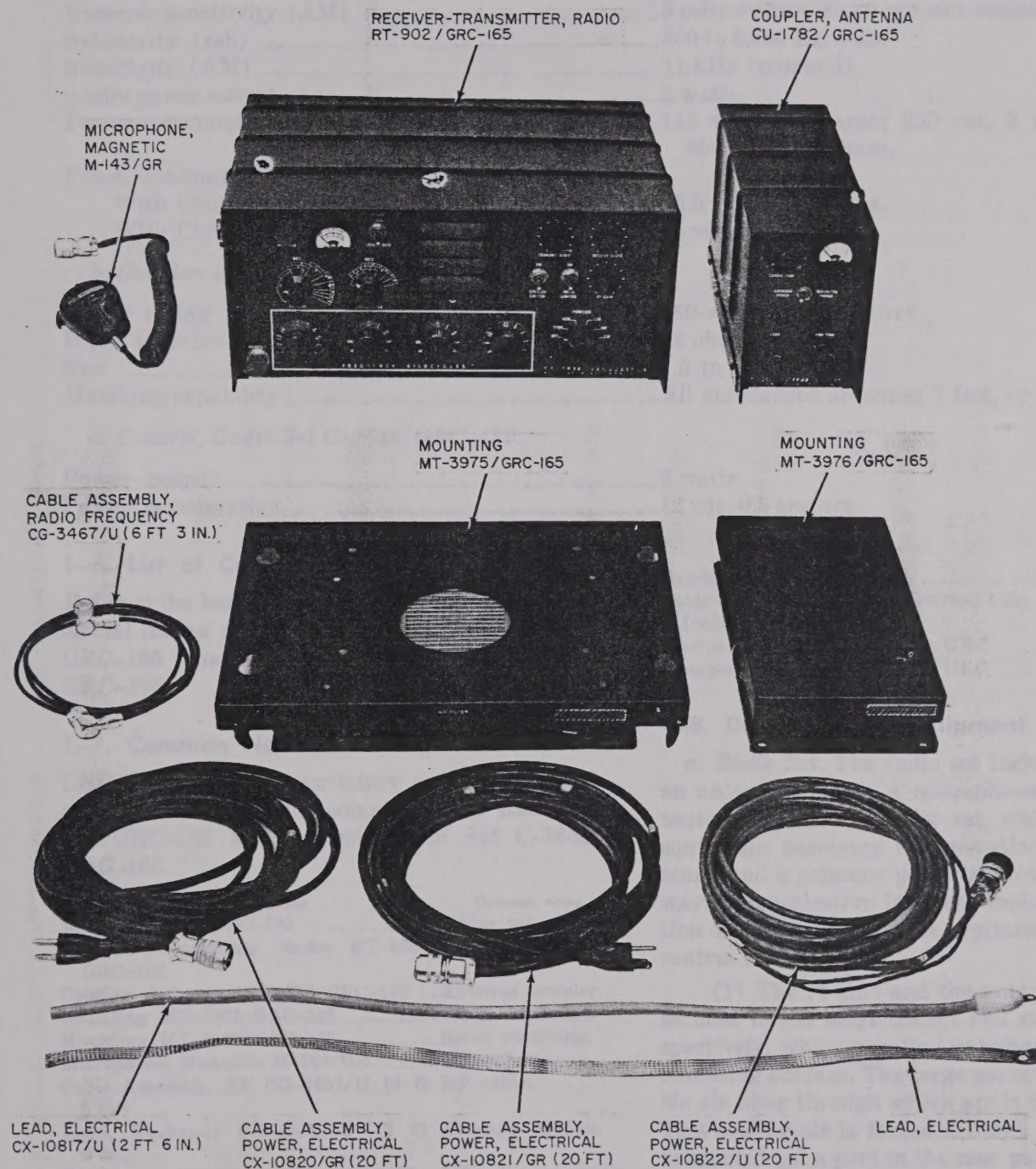
RADIO SET AN/GRC-165 AND
CONTROL, RADIO SET
C-7648/GRC-165

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HEADQUARTERS, DEPARTMENT OF THE ARMY

JULY 1970

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TM5820-759-12-2

Figure 1-1. Radio Set AN/GRC-165, less running spares.

Transmitter output impedance	52 ohms (swr 1.5 to 1, or better).
Carrier suppression	—50 db (nominal).
Undesired sideband suppression	—50 db.
Harmonic suppression	—45 db (nominal).
Intermodulation distortion	—35 db (nominal).
Receiver sensitivity (ssb)	1 microvolt for 10-db signal to noise ratio.
Receiver sensitivity (AM)	3 microvolts with 30-percent modulation.
Selectivity (ssb)	300 to 3,500 Hz, 6 db.
Selectivity (AM)	11 kHz (nominal).
Audio power output	2 watts.
Power consumption (ac)	115 vac, 4 amperes; 230 vac, 3 amperes; 50 to 60 Hz, single phase.
Power consumption (dc):	
With Chopper, Electronic CV-2487/URC	13.5 vdc, 28 amperes.
With Chopper, Electronic CV-2486/URC	26 vdc, 15 amperes.

b. Coupler, Antenna CU-1782/GRC-165.

Power rating	150-watt average power.
Input impedance	52 ohms.
Swr	1.5 to 1, or better.
Matching capability	All unbalanced antennas 9 feet, or longer.

c. Control, Radio Set C-7648/GRC-165.

Power output	2 watts.
Power consumption	12 vdc, 0.5 ampere.

1-6. List of Components

Refer to the basic issue items list (appx B) for an official listing of components for Radio Set AN/GRC-165 and Control, Radio Set C-7648/GRC-165.

1-7. Common Names

Listed below are nomenclature assignments with common names for the components of Radio Set AN/GRC-165 and Control, Radio Set C-7648/GRC-165.

Nomenclature	Common name
Radio Set AN/GRC-165	Radio set.
Receiver-Transmitter, Radio RT-902/GRC-165.	Rt unit.
Coupler, Antenna CU-1782/GRC-165	Antenna coupler.
Mounting MT-3975/GRC-165	Large mounting.
Mounting MT-3976/GRC-165	Small mounting.
Microphone, Magnetic M-143/GR	Microphone.
Cable Assembly, RF CG-3467/U (6 ft RF cable. 3 in.).	
Lead, Electrical CX-10817/U (2 ft Antenna lead-in. 6 in.).	
Cable Assembly, Power, Electrical CX-10820/GR (20 ft).	115-volt ac power cable.
Cable Assembly, Power, Electrical CX-10821/GR (20 ft).	230-volt ac power cable.
Cable Assembly, Power, Electrical CX-10822/U (20 ft).	Dc power cable.
Lead, electrical	Ground strap.
Control, Radio Set C-7648/GRC-165	Remote control.

Handset H-280/GRC-165	Handset.
Cable Assembly, Special, Electrical CX-10823/U (92 ft).	Remote cable.
Chopper, Electronic CV-2486/URC	26.0-volt chopper.
Chopper, Electronic CV-2487/URC	13.5-volt chopper.

1-8. Description of Equipment

a. Radio Set. The radio set includes an rt unit, an antenna coupler, a microphone, and interconnecting cables. The radio set, which includes all equipment necessary for operation except an antenna and a primary power supply, provides two-way communication in either mobile or fixed station use. In some radio set applications, the remote control will be used.

(1) The rt unit and the antenna coupler are secured to the large mount and small mount, respectively, which usually are bolted to a vehicular mounting surface. The large mount has a removable air filter through which air is drawn by a fan. This cooling air is forced through the rt unit and exhausted out a port in the rear panel.

(2) Except for the microphone at the rt unit front panel, all cable connections are made at the rear panels. Rear panel connections include the interconnecting transmission line, an antenna lead-in, a dc power cable, and (if used) the remote cable. All operating controls, meters, and speaker

are on the front panels of the units, which are housed in hand-portable, splashproof chassis with ruggedized covers.

(3) A power supply, contained in the rt unit, provides all the operating voltages for the radio set and the remote control. Differences in primary power requirements for the radio set are described in paragraph 1-10.

b. *Remote Control.* A complete remote control (fig. 1-2) includes the handset and the remote cable. The remote control, when used, provides remote operation and monitoring of the radio set keying and audio functions. The remote control is contained in a hand-portable, splashproof chassis with a ruggedized cover (painted olive drab). Operating controls, a HANDSET connector, and a speaker are mounted on the front panel. In some vehicle or fixed station installations, the remote control can be secured by an attached swivel mounting bracket and can be tilted to a convenient angle for ease of operation.

1-9. Additional Equipment Required

An antenna and a primary power source are not supplied with the radio set but are needed for operation. Although any whip or straight wire antenna 9 to 36 feet in length may be used, Antenna AS-2203/GRC-165 (fig. 2-5) and a dipole antenna are intended for use with the radio set. The primary power source must equal the voltage requirement and exceed the current requirement of the radio set.

1-10. Power Requirements

Rt units with a 26.0-volt chopper installed, can operate from either 26-volt direct current (dc), or 115- or 230-volt alternating current (ac) primary power. Rt units, with a 13.5-volt chopper installed, can operate on either 13.5-volt dc, 115-volt ac, or 230-volt ac primary power. Rt units without a chopper can be operated from ac power only.

CHAPTER 2

INSTALLATION

2-1. Unpacking Instructions and Packing Data

a. Packing Data. When packed for shipment, individual components of the radio set are placed in cartons, or plastic containers, which are packed in a wooden shipping crate. The remote control and the handset are packaged and shipped separately in corrugated cartons. A typical shipping crate is shown in figure 2-1.

b. Dimensions and Weight. The shipping crate is 22½ inches high by 34½ inches long by 17¼ inches wide, weighs 155 pounds, and occupies a volume of 7¾ cubic feet. The nominal dimensions and weights of the radio set components and accessories are given in the chart below.

Item	Dimensions (in.)			Weight (lb)
	Width	Depth	Height	
Rt unit.....	18½	14¼	7¾	59
Antenna coupler.....	5	14¼	7¾	9
CV-2486/URC.....	4⅜	4	2⅞	1½
CV-2487/URC.....	4⅜	4	2⅞	1½
Remote control.....	7½	5⅞	4¾	4
Large mount.....	17	12⅜	2¾	8
Small mount.....	7	12⅜	2½	3

c. Removal of Contents (fig. 2-1). The unpacking procedures are given in (1) through (7) below.

- (1) Cut and fold back the metal straps.

CAUTION

Do not attempt to pry off the wooden cover; equipment damage may result.

(2) Remove the nails from the wooden cover of the packing case with a nailpuller and lift off the wooden cover.

(3) Remove the corrugated filler and the corrugated support; then remove the corrugated cardboard fillers.

(4) Remove the cable assemblies surrounding the corrugated carton.

(5) With a knife or sharp instrument cut the tape that seals the inner corrugated carton and

open the flaps. Remove the filler material that surrounds the equipment.

(6) Remove the rt unit, the antenna coupler, the technical manual, and the running spares kit.

(7) Remove the rt unit and the antenna coupler from their plastic bags.

2-2. Checking Unpacked Equipment

a. Inspect the equipment for damage that may have occurred during shipment. If the equipment has been damaged, fill out and forward DD Form 6 (para 1-3b).

b. Check to see that the equipment is complete as listed on the packing slip or as listed in appendix B. Report all discrepancies in accordance with the instructions given in TM 38-750.

c. If the equipment has been used or reconditioned, check to see whether it has been changed by a modification work order. If the equipment has been modified, the MWO number will appear on the front panel, or near the nomenclature plate.

2-3. Radio Set Installation

Figure 2-2 is a pictorial cabling diagram.

a. Mobile Installation. Installation procedures for mobile application of the radio set are given below. Figure 2-3 shows a typical installation in a trailer.

NOTE

The antenna must be located within 3 feet of the antenna coupler (the antenna coupler is used when the whip antenna is used).

(1) Secure the large mount and the small mount to the vehicle or trailer floor.

(2) Attach and secure the rt unit and the antenna coupler to their respective mount.

(3) Attach antenna and connect to antenna coupler using the antenna lead-in.

(4) Connect RF cable between rt unit ANTENNA connector (fig. 2-2), and antenna coupler INPUT connector.

CHAPTER 1

INTRODUCTION

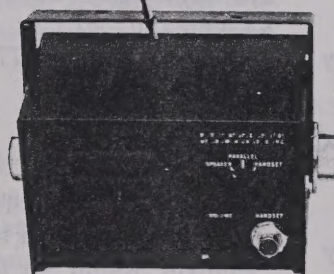
Section I. GENERAL

1-1. Scope

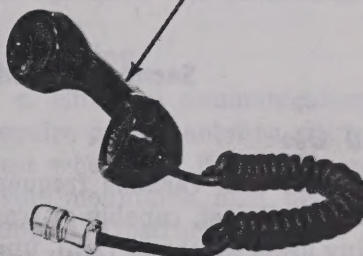
a. This manual describes Radio Set AN/GRC-165 (radio set) (fig. 1-1) and Control. Radio

Set C-7648/GRC-165 (fig. 1-2), and covers their installation, operation, troubleshooting, and organizational maintenance. It also includes instruc-

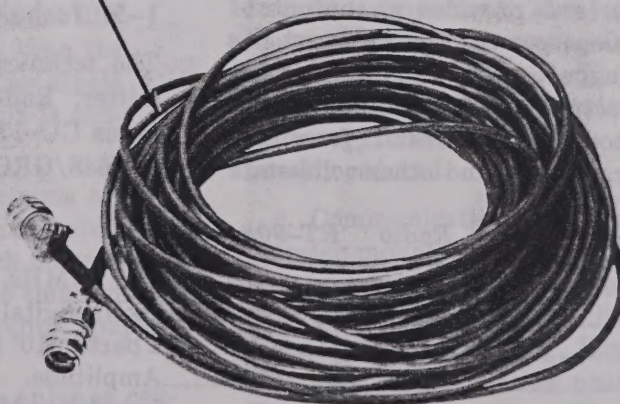
CONTROL, RADIO SET
C-7648/GRC-165



HANDSET
H-280/GRC-165



CABLE ASSEMBLY,
SPECIAL PURPOSE, ELECTRICAL
CX-10823/U (92 FT)



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Figure 1-2. Control, Radio Set C-7648/GRC-165.

tions for using the radio set in usual and unusual conditions and for extending the transmission distance beyond the normal range.

b. The basic issue items list (BIIL) appears in appendix B, the maintenance allocation chart appears in appendix C, and the repair parts and special tool lists appear in appendix D.

NOTE

Appendixes B, C, and D are current as of 22 May 1970.

1-2. Indexes of Publications

a. *DA Pam 310-4*. Refer to the latest issue of DA Pam 310-4 to determine whether there are new editions, changes, or additional publications pertaining to the equipment.

b. *DA Pam 310-7*. Refer to the latest issue of DA Pam 310-7 to determine whether there are modification work orders (MWO's) pertaining to the equipment.

1-3. Forms and Records

a. *Reports of Maintenance and Unsatisfactory*

Equipment. Use equipment forms and records in accordance with instructions given in TM 38-750.

b. *Report of Packaging and Handling Deficiencies*. Fill out and forward DD Form 6 (Report of Packaging and Handling Deficiencies) as prescribed in AR 700-58 (Army), NAVSUP Publication 378 (Navy), AFR 71-4 (Air Force), and MCO P4610-5 (Marine Corps).

c. *Discrepancy in Shipment Report (DISREP) (SF 361)*. Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55-38 (Army), NAVSUP Pub 459 (Navy), AFM 75-34 (Air Force), and MCO P4610.19 (Marine Corps).

d. *Reporting of Equipment Manual Improvements*. Reporting of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to Publications) and forwarded direct to Commanding General, U.S. Army Electronics Command, ATTN: AMSEL-ME-NMP-AD, Fort Monmouth, N.J. 07703.

Section II. DESCRIPTION AND DATA

1-4. Purpose and Use

Radio Set AN/GRC-165 is a variable frequency single sideband (ssb) radio set, capable of transmitting and receiving lower sideband (lsb), upper sideband (usb), continuous wave (cw), and amplitude modulation (AM) signals to be used in mobile, transportable, or fixed installations. The radio set can be operated on any frequency assigned in the 2- to 15-megahertz (MHz), high frequency (hf) range, and provides an output of 100-watt peak envelope power. The radio set has been designed for rugged service and has a splash-proof case. Compactness, high reliability, and moderate power consumption result from the maximum use of transistors and other solid-state

devices. Digital frequency selection is provided for both receiving and transmitting. When used with Control, Radio Set C-7648/GRC-165, keying and audio functions of Radio Set AN/GRC-165 can be remotely extended to distances of up to 92 feet (29.04 meters) (the length of Cable Assembly, Special Purpose, Electrical C-10823/U) from the radio set.

1-5. Technical Characteristics

The technical characteristics of Receiver-Transmitter, Radio RT-902/GRC-165; Coupler, Antenna CU-1782/GRC-165; and Control, Radio Set C-7648/GRC-165 are listed in *a*, *b*, and *c* below.

a. *Receiver-Transmitter, Radio RT-902/GRC-165.*

Frequency range	2 to 15 MHz.
Resolution	1 kHz digital (13,000 channels).
Frequency stability	1 part in 10 ⁶ per month.
Modulation	Amplitude.
Type of transmission	Usb, lsb, AM (compatible), and cw.
Power output	Ssb: 100-watt peak envelope power. Cw: 100 watts average. AM: 25-watt carrier (nominal).
Range	30 miles (42 km).

(5) Connect braided ground strap between rt unit GROUND post, and antenna coupler GROUND post.

CAUTION

Set the rt unit FUNCTION switch to OFF and power selector switch S1 (at rear panel of rt unit) to DC. Observe polarity of the dc power cable and the power source.

(6) Connect the dc power cable to the DC connector on the rt unit, and the spade lug to the vehicle battery or generator (red to positive, black to negative).

(7) If the remote control is to be used, connect the remote cable to the REMOTE connector on the rt unit and to the connector at the rear of the remote control.

(8) Store technical manuals, running spares, and extra cables in a designated or protected place.

b. Fixed Station Installations. Installation procedures for fixed station operation are given below.

NOTE

Refer to paragraph 2-4 and figure 2-2. If operation requires the use of the antenna coupler, place it not farther than 3 feet away from the antenna. The rt unit can be installed at a distance of up to approximately 100 feet (30.5 meters) from the antenna coupler, or approximately 92 feet (29.04 meters) from the remote control; however, *best* operation is achieved by using the rt unit mounted next to the antenna coupler, with the remote control located at a convenient distance away (some distance less than the length of the remote cable). The dipole antenna or straight wire antenna is connected direct to the rt unit.

(1) Place the rt unit and the antenna coupler (if the whip antenna or an unbalanced antenna is used) at the desired location. If shock mounting is used, secure the large mount and the small mount and attach the rt unit and the antenna coupler, respectively.

(2) Connect the antenna to the antenna coupler ANT. connector.

(3) Connect the RF cable between the rt unit ANTENNA connector and the antenna coupler INPUT connector.

(4) Connect the braided ground strap between the rt unit GROUND post and the antenna coupler GROUND post.

CAUTION

Observe polarity of the power cable and the power source. If operating on ac primary power, make sure that power selector switch S1, at the rear of the rt unit, is set to the position corresponding to the primary power voltage.

(5) Connect the dc power cable to the rt unit DC connector if dc primary power is being used. For ac operation, connect either the 115-volt ac power cable or the 230-volt ac power cable to the rt unit 115 VAC or 230 VAC connector, respectively.

(6) If remote control operation is to be used install the remote cable to the rt unit REMOTE connector and to the connector at the rear of the remote control.

(7) Store technical manuals, running spares, and extra cables in a designated or protected place.

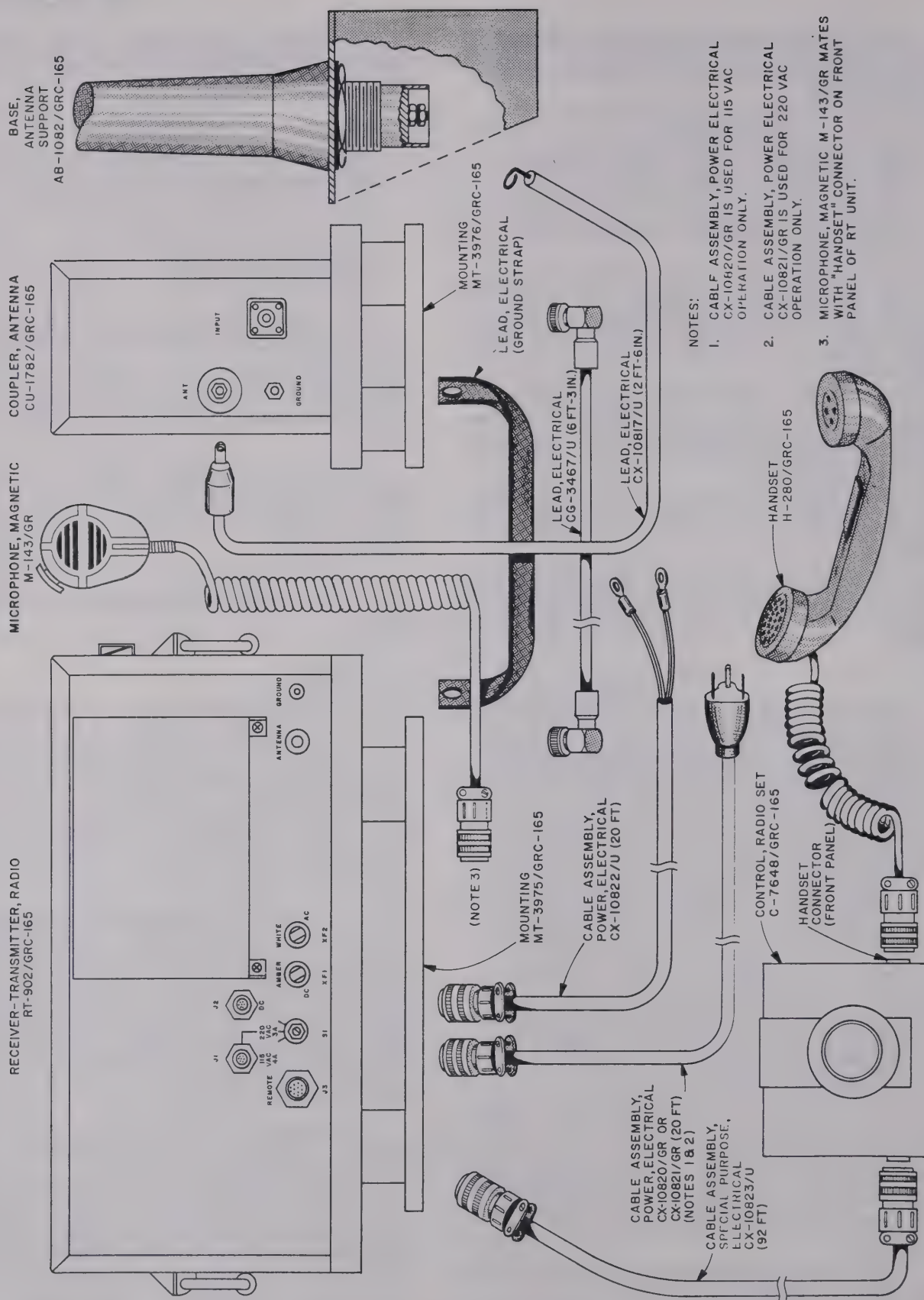
2-4. Siting

a. Effective communications and antijamming require proper antenna siting. A site is generally best when it is flat, high, and clear. If possible, avoid mountains, hills, heavily wooded areas, and jungles. Obstructions, such as buildings (especially those containing large amounts of metal), trees, or large objects should not be near the antenna.

b. The type of surface where the antenna is located and over which radiofrequency (RF) energy travels is important. The best surfaces are clay, loam, marsh or swamp, alkali soil, and water (lakes, bays, and oceans). The worst are coral, dry sand, and rock. Dense jungles are especially poor because groundwave range (para 2-5a) will be greatly reduced.

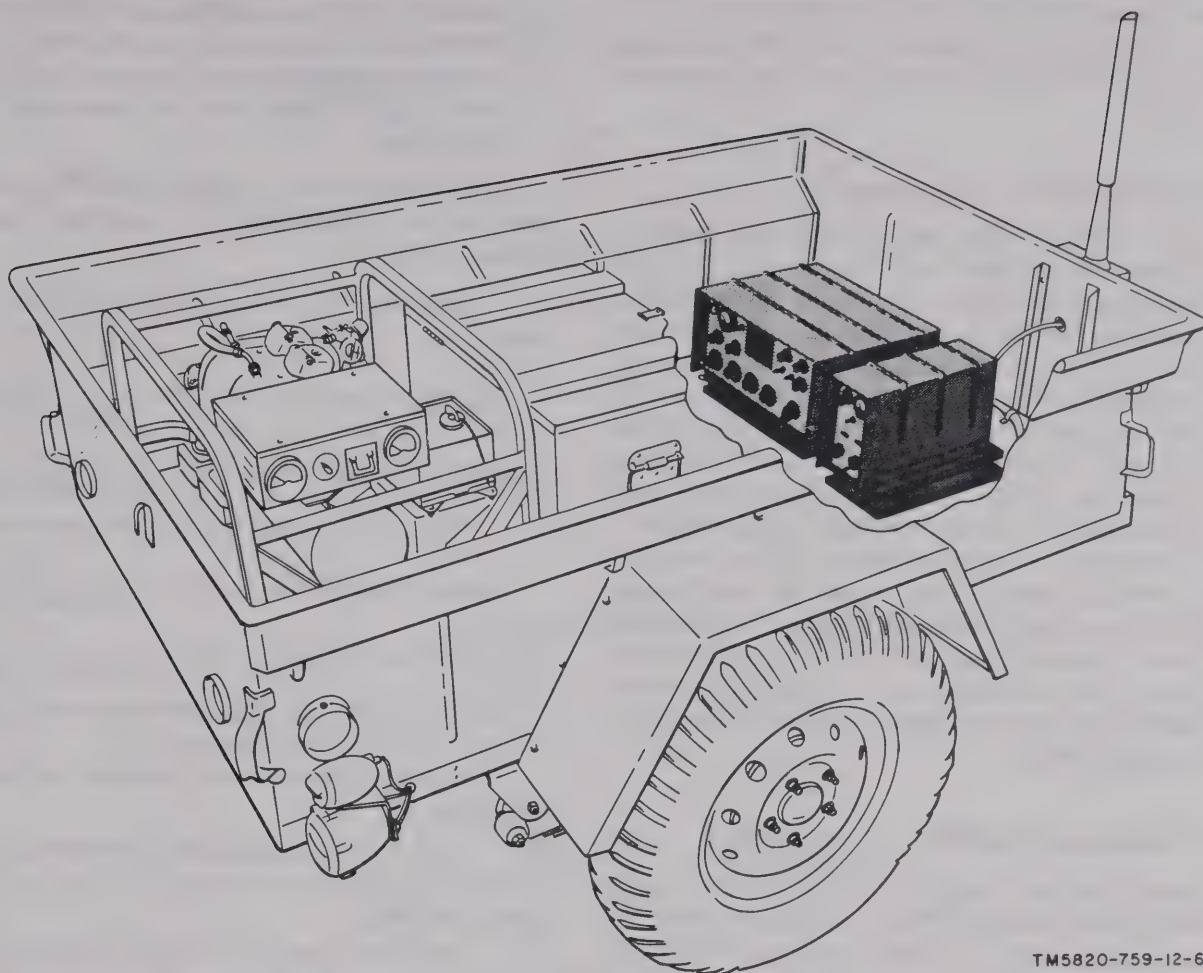
c. Communications can usually be established between mountains, hills, and obstructions if there is an unobstructed path direct to the desired remote station. Use this condition to reduce the effects of enemy jamming. Block the jamming signals with an obstruction near the antenna in the direction of the source. If possible, provide an unobstructed path to the desired signal.

d. Avoid interference from power and telephone lines, radar sets, and field hospitals. If possible,



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Figure 2-2. Radio Set AN/GRC-165 and Control, Radio Set C-7648/GRC-165 pictorial cabling diagram.



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Figure 2-3. Radio Set AN/GRC-165, typical trailer installation

try several locations within the general area and select the one that provides best signal reception from the desired stations.

2-5. Ranging

a. Under most conditions, a reliable communications range of 30 miles is provided by the radio set. Greater ranges require using the current propagation conditions to their full advantage as well as providing a good antenna and site. Both groundwave propagation and skywave propagation should be used for their advantages, and each should be considered when the operating frequencies are selected.

b. The groundwave propagation range, which is nominally 30 miles, can be increased to 100 miles

by using the lowest available frequency and the longest antenna, such as either a 35-foot whip antenna, or a straight wire antenna. The longwire antenna length is determined by the following equation:

$$\text{Length (in feet)} = \frac{490}{\text{frequency MHz}}$$

c. Skywave propagation refers to RF signals reflected back to the earth from the ionosphere. This enables communications over distances greater than would be possible with groundwave propagation. When using skywave propagation, always start with the highest available frequency and work down the frequency range until contact is made. Since the ionosphere changes with the time of day, daytime frequencies will be higher than

nighttime. Try 9 to 15 MHz in the daytime and 6 to 12 MHz during the night. Predictions are published *monthly* in TB 11-499-series (TO 31-3-28-2) of the best frequencies for utilizing skywave propagation between any two points on the earth.

2-6 Recognition of Jamming

It is likely that under real or simulated tactical conditions the rt unit will be jammed by the enemy. Unusual noises or strong interference heard from the rt unit may be enemy jamming, signals from a friendly station, or noise from a local source, or the rt unit may be defective. To determine whether the interference is originating in the rt unit, disconnect the antenna, or short the ANT terminal to the chassis. If the interference continues, the rt unit is defective. If the interference disappears, enemy jamming may be present. The jamming signals are typed as continuous wave or modulated. These signals may be intended to block a single frequency (this is called spot jamming), or the enemy may use one or several transmitters to jam or block a band of frequencies (barrage jamming).

2-7. Antenna Assembly

Antennas are not supplied with the radio set; however, any straight-wire antenna, 9 feet or longer, can be used. A dipole antenna and a 16-foot whip antenna are intended for use with the radio set. Greatest range is provided by the dipole antenna; however, directivity, resonance (operationally limited to one frequency), and erection time usually limit this antenna to specific fixed station functions.

a. Dipole Antenna. A dipole antenna is usually erected between two supports as shown in A, figure 2-4. Because of terrain or the availability of only one support, the one-support dipole antenna (inverted V), shown in B, figure 2-4, can be used. Assemble and erect the dipole antenna as follows:

NOTE

Dipole antennas should be erected perpendicular to the direction of communication and connected directly to the rt unit ANTENNA connector.

(1) Attach each antenna wire to the dipole fixture.

CAUTION

Damage to the rt unit will result if operation is tried on a frequency other than the resonant frequency of the dipole. If operating frequency is changed, adjust the length of the dipole as described in (2) below.

(2) Determine the length of each leg from the appropriate formula for the operating frequency of the rt unit.

(a) For the two support (horizontal) dipole:

$$\text{Length of each wire (feet)} = \frac{234}{\text{frequency (MHz)}}$$

$$\text{Length of each wire (meters)} = \frac{71.3}{\text{frequency (MHz)}}$$

(b) For the inverted V-dipole antenna:

$$\text{Length of each wire (feet)} = \frac{245}{\text{frequency (MHz)}}$$

$$\text{Length of each wire (meters)} = \frac{74.5}{\text{frequency (MHz)}}$$

(3) Connect the dipole antenna lead-in to the rt unit ANTENNA connector.

(4) Erect the antenna between the supports as follows:

(a) The two-support (horizontal) dipole antenna will be approximately 20 feet, or 6 meters, in height.

(b) The inverted V-dipole antenna connections at end poles should be a minimum of 6 feet, or approximately 1.9 meter, from the ground. The center pole should be one-third of the total length of the antenna wire. Route the lead-in down the pole.

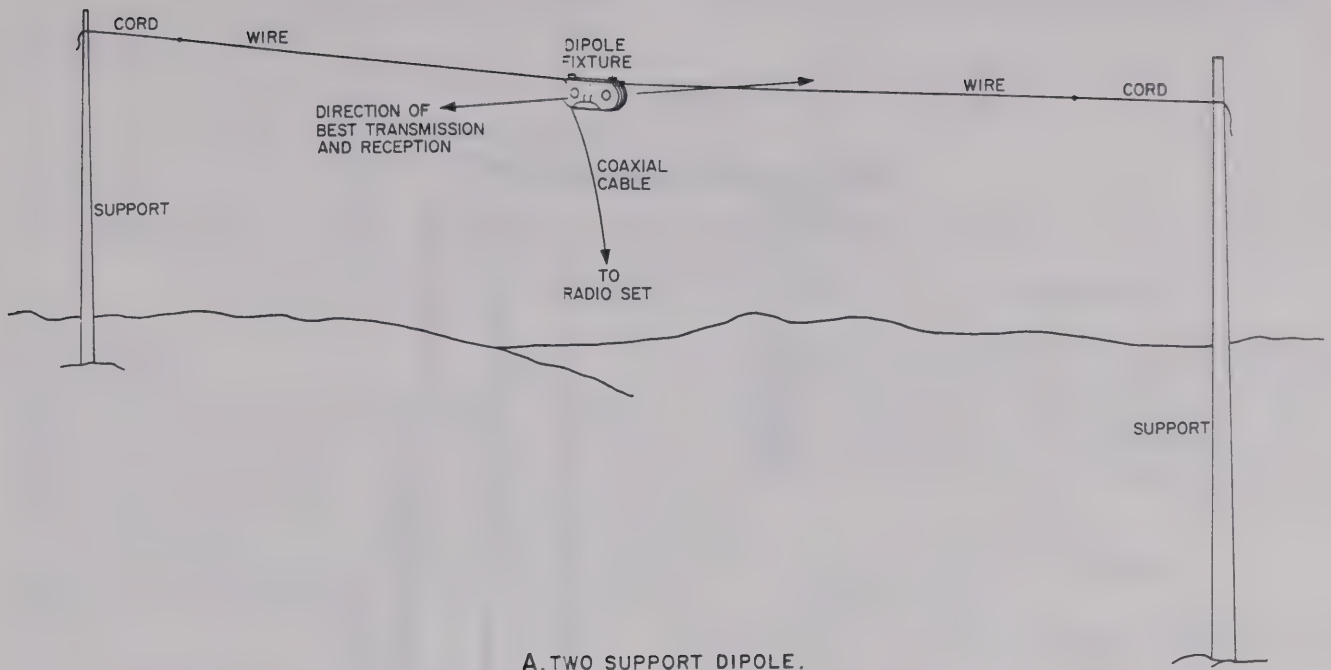
NOTE

Operator and organizational maintenance personnel should be familiar with the requirements of TB SIG 291 before attempting installation and operation of the equipment with a whip antenna.

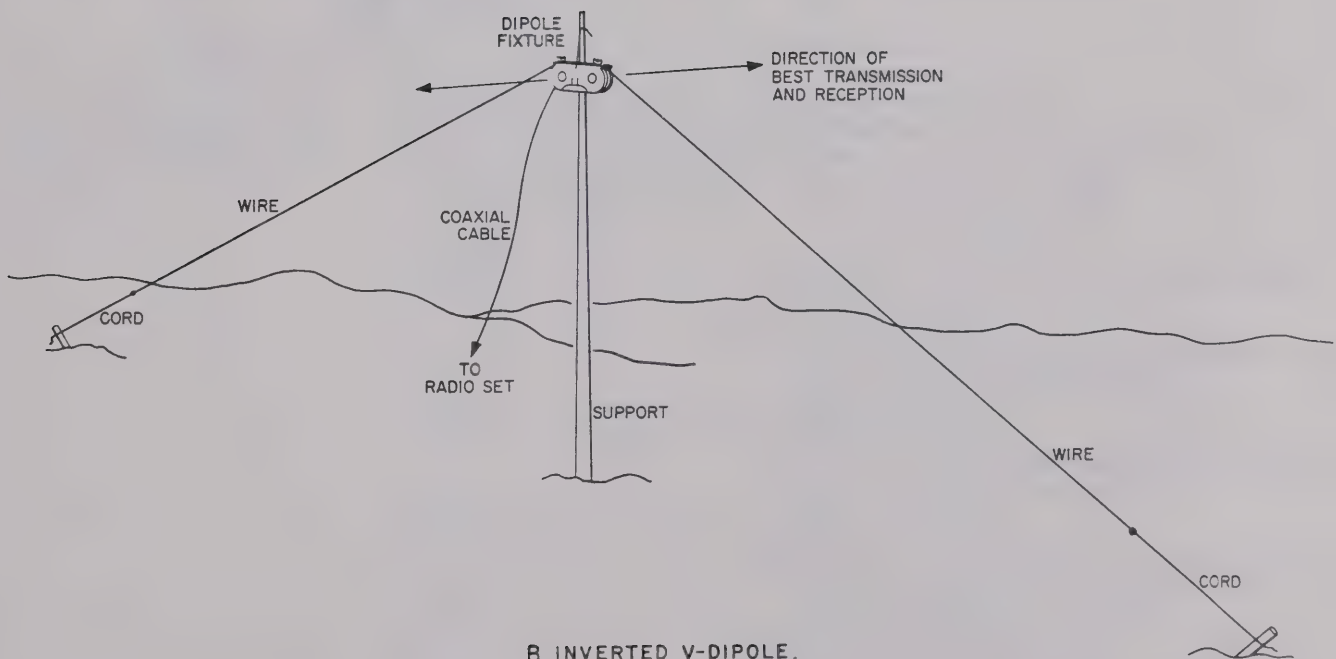
b. Antenna AS-2203/GRC-165 (16-Foot Whip Antenna) (fig. 2-5). This antenna consists of four 4-foot sections with a support base.

(1) Attach Base, Antenna Support AB-1082/GRC-165 (antenna support), through a $1\frac{13}{16}$ -inch hole and secure it with the nut supplied.

(2) Assemble the four antenna sections by screwing them end to end; then screw the whip antenna assembly into the antenna support threads.



A. TWO SUPPORT DIPOLE.



B. INVERTED V-DIPOLE.

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Figure 2-4. Typical dipole antenna installation.

(3) Connect the antenna lead-in wire to the brass terminal on the antenna support (fig. 2-2).

Use a soldered terminal; be careful to remove all flux with trichloroethane.



Figure 2-5. Antenna AS-2203/GRC-165.

CHAPTER 3

OPERATING INSTRUCTIONS

Section I. OPERATOR CONTROLS, INDICATORS, AND CONNECTORS

3-1. General

This section describes the function of each control, indicator, and connector of the radio set and the remote control. Haphazard operation and improper setting of controls can result in poor operation and possible damage to the equipment. Become familiar with the function of each control before operating the equipment. To prevent damage to the radio set, observe the following precautions:

a. Check to see that switch S1 (at the rear panel of the rt unit) is set at the position corresponding to the voltage of the primary power source being used before primary power is applied.

b. During preliminary tuning, rotate the rt unit TRANSMIT AUDIO control fully clockwise to TUNE. This action automatically limits the rt unit power output to 25 watts to prevent damage to the rt unit and the antenna coupler during tuning.

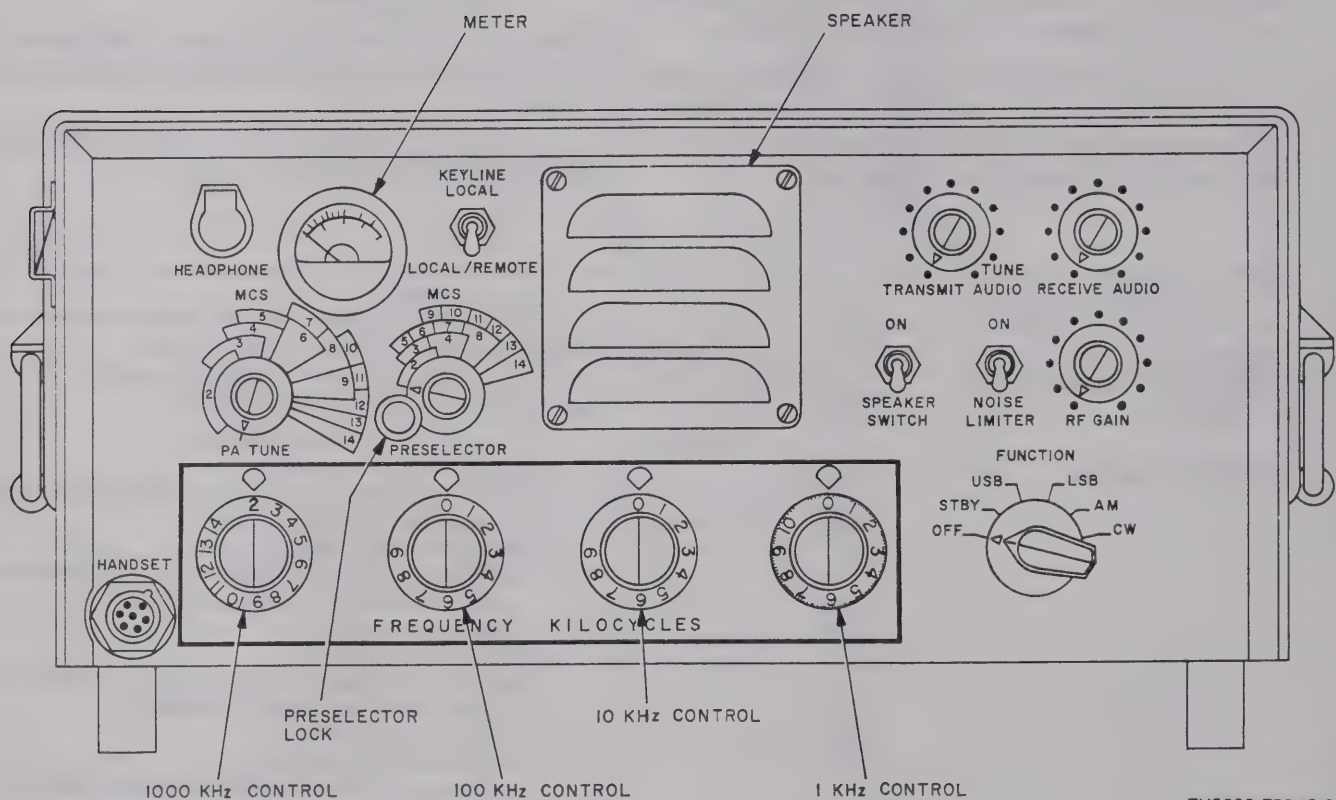
3-2. Rt Unit Controls, Indicators, and Connectors

The rt unit operating controls, indicators, and connectors and their function are listed in *a* and *b* below.

a. *RT Unit Front Panel Switches, Controls, Indicators, and Connectors* (fig. 3-1).

Control, indicator, or connector	Function
HANDSET connector.....	Used for local handset, microphone, or hand key connections to rt unit.
FREQUENCY KILOCYCLES controls (4).	Select operating frequency in kHz: 1,000, 100-, 10-, and 1-kHz increments. The 1-kHz knob is pulled out for vernier tuning between channels.
	<i>Switch position</i> <i>Equipment response</i>
FUNCTION switch.....	<div>OFF..... Disconnects primary power.</div> <div>STBY..... Applies power to circuits requiring warmup before operation.</div> <div>USB..... <div><i>a.</i> Applies primary power.</div> <div><i>b.</i> Selects upper sideband.</div> <div><i>c.</i> Receive and transmit switching are controlled by microphone or handset push-to-talk switch.</div> </div> <div>LSB..... <div><i>a.</i> Applies primary power.</div> <div><i>b.</i> Selects lower sideband.</div> <div><i>c.</i> Receive and transmit switching are controlled by microphone or handset push-to-talk switch.</div> </div> <div>AM..... <div><i>a.</i> Applies primary power.</div> <div><i>b.</i> Selects amplitude modulation.</div> <div><i>c.</i> Receive and transmit switching are controlled by microphone or handset push-to-talk switch.</div> </div> <div>CW..... <div><i>a.</i> Applies primary power.</div> <div><i>b.</i> Selects continuous wave operation.</div> <div><i>c.</i> Transmitter is switched and held on for 1 second by closing hand key, after which it automatically returns to receive if hand key is released.</div> </div>
RF GAIN control.....	Adjusts receiver sensitivity.
NOISE LIMITER switch.....	Switches noise limiter circuitry on and off.
SPEAKER SWITCH.....	Switches speaker on and off.
PRESELECTOR control.....	Adjusts tuning of RF amplifier.
PA TUNE control.....	Adjusts tuning of power amplifier.
HEADPHONE connector.....	Allows monitoring of audio signals with headphones.

Control, indicator, or connector	Function	
	<i>Mode</i>	<i>Action</i>
Meter.....	Transmit.....	Indicates transmitter power output.
	Receive.....	Indicates received signal strength.
	<i>Switch position</i>	<i>Equipment response</i>
KEYLINE switch.....	LOCAL.....	Permits local keying at HANDSET connector only.
	LOCAL/REMOTE.....	Allows remote keying (at REMOTE connector) in addition to local keying.
Speaker.....	For monitoring audio signals locally.	
RECEIVE AUDIO control.....	Adjusts local received audio level.	
TRANSMIT AUDIO control.....	Adjusts transmitter drive level.	



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Figure 3-1. Receiver-Transmitter, Radio RT-902/GRC-165 front panel.

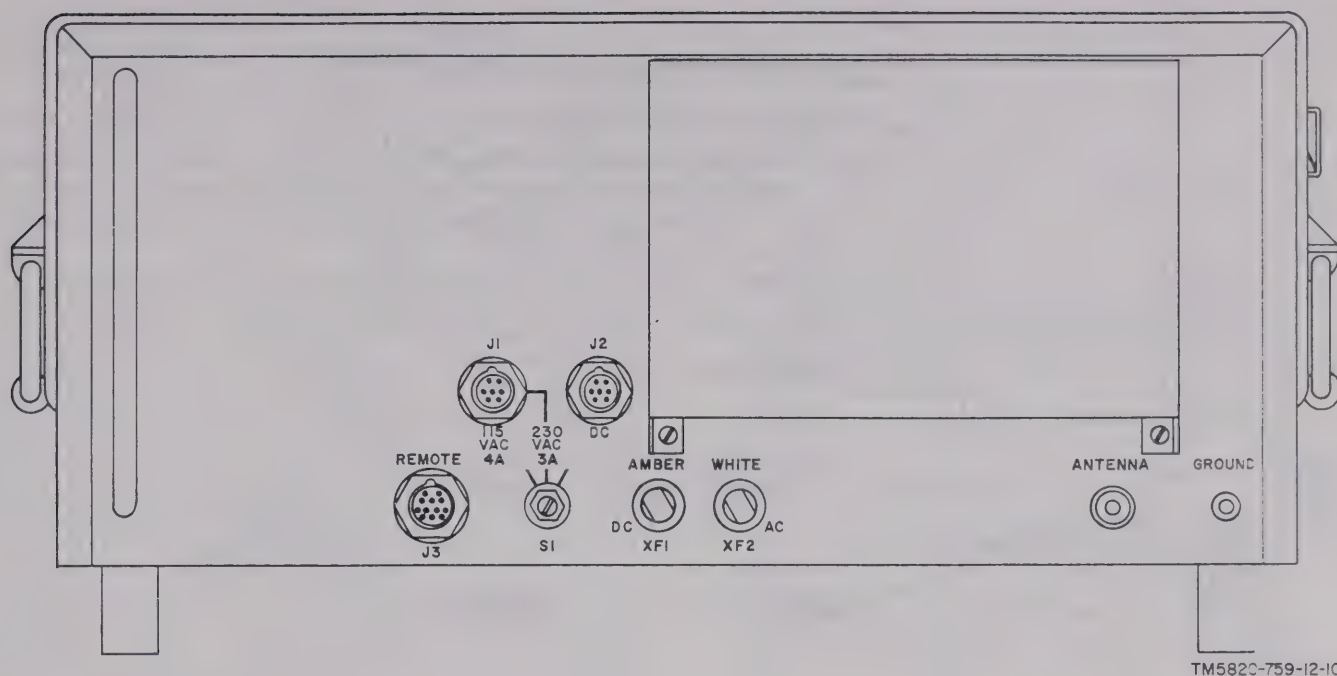


Figure 3-2. Receiver-Transmitter, Radio RT-902/GRC-165, rear panel.

b. Rt Unit Rear Panel Switch, Indicators, and Connectors (fig. 3-2).

Control, or connector	Function								
REMOTE connector.....	Connector for remote cable.								
Power selector switch S1.....	Permits operation on either ac or dc primary power by selecting proper power connector and internal circuitry.								
	<table> <tr> <th>Switch position</th><th>Action</th></tr> <tr> <td>115 VAC 4A.....</td><td>Permits operation with 115-volt ac power at J1.</td></tr> <tr> <td>230 VAC 3A.....</td><td>Permits operation with 230-volt ac power at J1.</td></tr> <tr> <td>DC.....</td><td>Permits operation with 13.5- or 26.0-volt dc power at J2, depending on which dc chopper is installed in rt unit.</td></tr> </table>	Switch position	Action	115 VAC 4A.....	Permits operation with 115-volt ac power at J1.	230 VAC 3A.....	Permits operation with 230-volt ac power at J1.	DC.....	Permits operation with 13.5- or 26.0-volt dc power at J2, depending on which dc chopper is installed in rt unit.
Switch position	Action								
115 VAC 4A.....	Permits operation with 115-volt ac power at J1.								
230 VAC 3A.....	Permits operation with 230-volt ac power at J1.								
DC.....	Permits operation with 13.5- or 26.0-volt dc power at J2, depending on which dc chopper is installed in rt unit.								
DC fuse XF1.....	Dc primary power fuse: 25 amperes (type AGC) for 13.5-volt dc operation, 15 amperes (type AGC) for 26.0-volt dc operation.								
AC fuse XF2.....	Ac primary power fuse: 4 amperes (type MTL) for 115 volts ac, 3 amperes (type AGC) for 230 volts ac.								
ANTENNA connector.....	Connector for long wire antenna, dipole antenna, or antenna coupler.								
GROUND connector.....	External ground terminal.								
DC connector.....	Dc primary power connector.								
115 VAC/230 VAC connector.....	Ac primary power connector.								

3-3. Antenna Coupler Switches, Controls, Indicators, and Connectors

connectors of the antenna coupler and their function are listed below.

The operating switches, controls, indicators, and

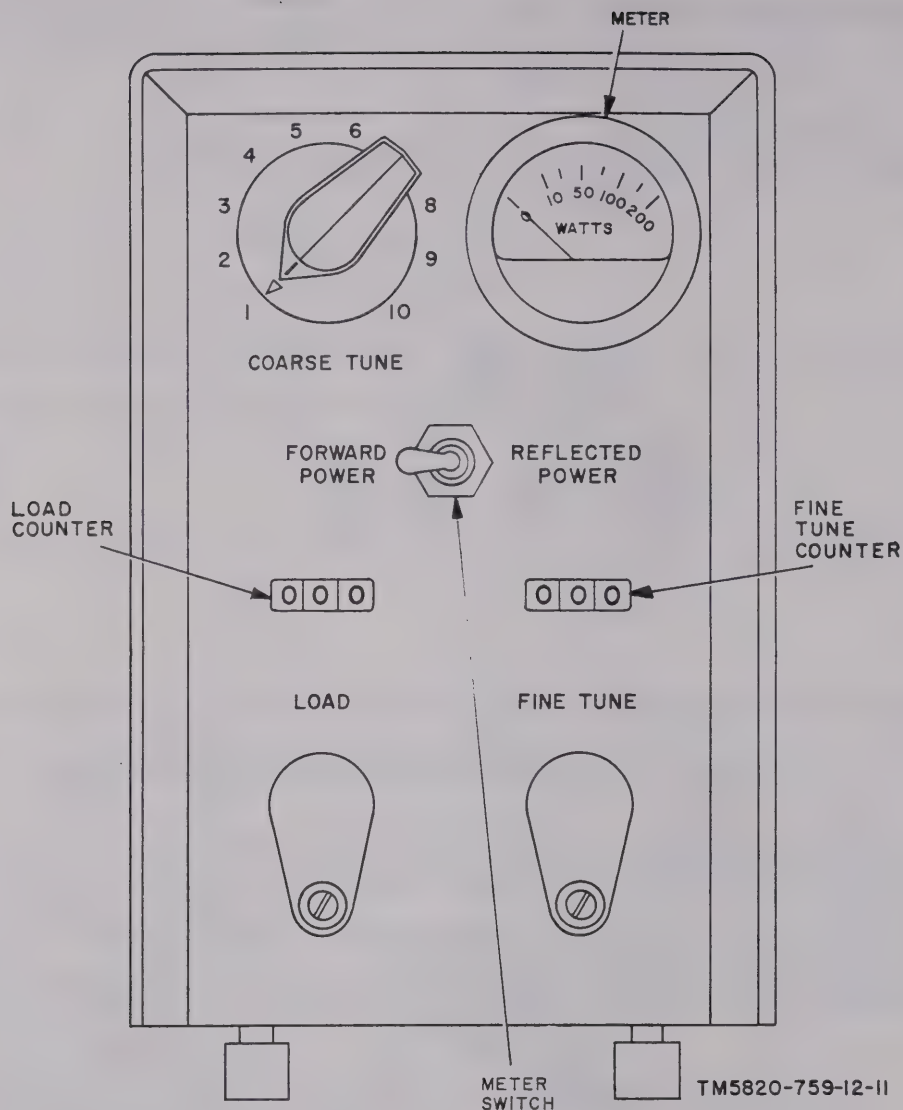


Figure 3-3. Coupler, Antenna CU-1782/GRC-165, front panel.

a. Antenna Coupler Front Panel Switches, Controls, and Indicators (fig. 3-3).

Control, indicator, or connector	Function
COURSE TUNE switch.....	Selects a fixed element in matching network.
LOAD control.....	Vernier control for tuning to resonance in matching network.
Load counter.....	Digital readout of LOAD control position.
FINE TUNE control.....	Adjusts matching network to minimize reflected power.
Fine tune counter.....	Digital readout of FINE TUNE control position.
Meter switch.....	Selects meter to indicate forward or reflected power.
Meter.....	Indicates range of forward and reflected power.

b. Antenna coupler rear Panel Connectors (fig.3-4).

Connectors	Function
INPUT connector.....	Connects rt unit RF cable to antenna coupler.
ANT connector.....	Connects antenna lead-in to antenna coupler.
GROUND connector.....	Connects external ground to antenna coupler.

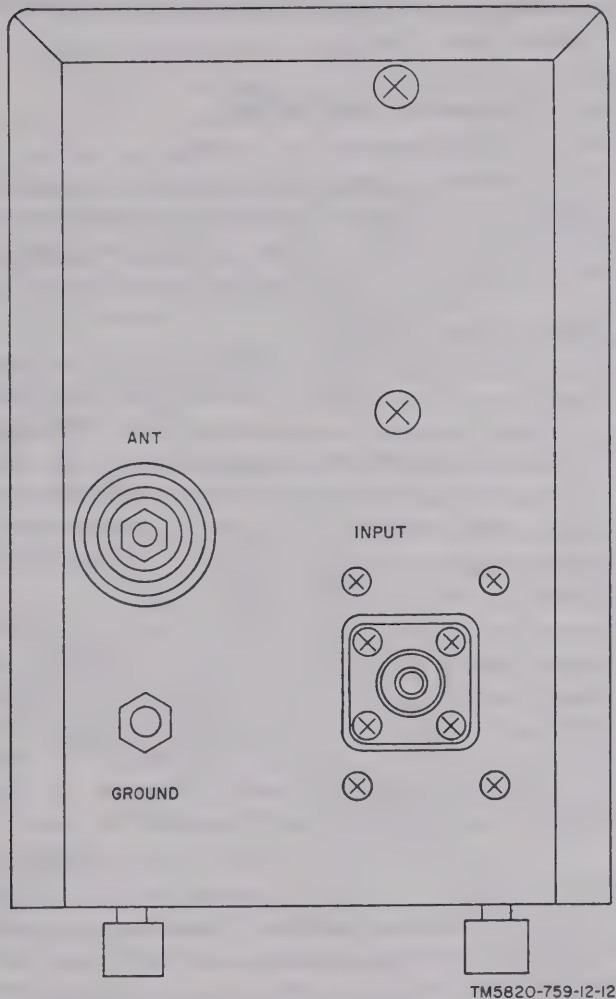


Figure 3-4. Coupler, Antenna CU-1782/
GRC-165, front panel.

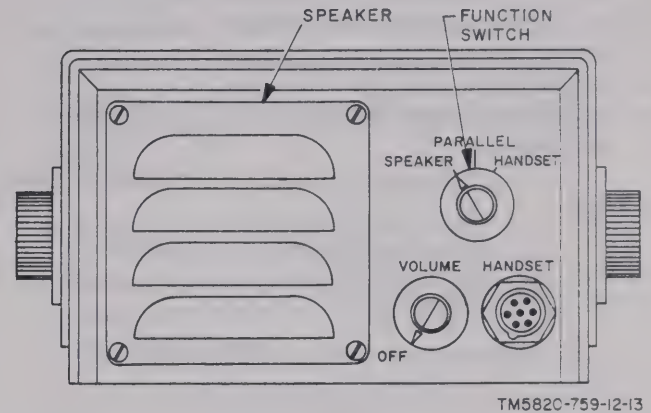


Figure 3-5. Control Radio Set C-7648/
GRC-165, front panel.

3-4. Remote Control Switch, Control, Speaker, and Connectors

(fig. 3-5)

The switches, control, speaker, and connectors of the remote control and their function are listed below.

NOTE

The connector for the remote cable is located at the rear of the remote control and is not shown in figure 3-5.

Controls, and connectors	Function								
VOLUME control and OFF switch.....	Switches remote control primary power and key line, and controls audio amplifier gain. In OFF position, primary power is switched off and rt unit key line is open.								
HANDSET connector.....	Provides remote handset, microphone, or hand key connections.								
Function switch.....	<table border="0"> <tr> <th>Switch position</th><th>Equipment response</th></tr> <tr> <td>SPEAKER.....</td><td>Allows audio output from rt unit to speaker only.</td></tr> <tr> <td>HANDSET.....</td><td>Allows audio output from rt unit to handset only.</td></tr> <tr> <td>PARALLEL.....</td><td>Allows audio output from rt unit to both speaker and handset.</td></tr> </table>	Switch position	Equipment response	SPEAKER.....	Allows audio output from rt unit to speaker only.	HANDSET.....	Allows audio output from rt unit to handset only.	PARALLEL.....	Allows audio output from rt unit to both speaker and handset.
Switch position	Equipment response								
SPEAKER.....	Allows audio output from rt unit to speaker only.								
HANDSET.....	Allows audio output from rt unit to handset only.								
PARALLEL.....	Allows audio output from rt unit to both speaker and handset.								
Speaker.....	For monitoring audio output of rt unit.								
J2 connector (located at rear panel (not shown)).	Provides connection to remote cable for connecting rt unit to remote control.								

Section II. OPERATION UNDER USUAL CONDITIONS

3-5. Types of Operation

a. The radio set may be operated either locally or remotely using voice or cw modulation. The radio set is capable of transmitting and receiving in the following modes:

- (1) Single sideband, selectable upper (usb) or lower (lsb).
- (2) Amplitude modulation (AM).
- (3) Continuous wave (cw).

b. Procedures for operating the equipment are as follows:

- (1) Preliminary starting procedures (para 3-6).
- (2) Operating instructions (para 3-7).
- (3) Remote control operation (para 3-8).

3-6. Preliminary Starting Procedures

CAUTION

Check to see that switch S1 at the rear of the rt unit (fig. 3-2) is set at the correct position for the primary power being used.

a. Set the FUNCTION switch (fig. 3-1) at STBY. The radio set will stabilize in less than 20 minutes, but can be operated with decreased frequency stability and accuracy within 1 minute.

b. Rotate the TRANSMIT AUDIO control clockwise until it *clicks* into the TUNE detent.

c. Rotate the RECEIVE AUDIO control fully counterclockwise.

d. Set the SPEAKER SWITCH to the desired position. Tactical conditions may require silence; therefore, the use of a handset or headset would be necessary. Set the SPEAKER SWITCH to the off (down) position to silence the front panel speaker.

e. After warmup, select the operating frequency with the FREQUENCY KILOCYCLES rotary switches. The frequency is selected from left to right, with the extreme left switch selecting the 1,000-kHz component of the operating frequency, the midleft switch selecting the 100-kHz digit, the midright switch selecting the 10-kHz digit, and the extreme right switch selecting the 1-kHz digit.

WARNING

Do not operate the radio set in the transmit mode without first connecting the an-

tenna system. Injury to personnel and damage to equipment may result.

NOTE

Tuning with RF power will break radio silence.

f. Rotate the FUNCTION switch to the desired mode of operation.

3-7. Operating Instructions

a. Receiver Tuning.

(1) If a handset, or a headset with microphone, is used, turn the SPEAKER SWITCH off.

(2) Set the RF GAIN control fully clockwise.

(3) Adjust the RECEIVE AUDIO for a comfortable listening level.

(4) Set the PRESELECTOR control substantially below the selected operating frequency band and tune clockwise for the first audible noise peak. If a transmission by another station is being made on the operating frequency, tune clockwise for a peak meter indication. To avoid spurious signals, always tune the PRESELECTOR clockwise from below the operating frequency.

(5) During tuning, and when the received signal indicates an off frequency condition, pull out the extreme right-hand FREQUENCY KILOCYCLES switch knob and vernier tune as a (0 to 10 kHz) variable frequency oscillator. To return to digital frequency selection, rotate the knob while pushing it in toward the panel.

(6) The RF GAIN control normally remains in the fully clockwise position for maximum sensitivity. Reduce the gain when receiving very strong signals, and to reduce background noise, by tuning the control counterclockwise. To reduce background noise between speech syllables, adjust the RF GAIN control to produce approximately a one-half unit (meter indication) fluctuation during reception.

b. Transmitter Tuning.

CAUTION

Correct antenna or load must be connected to the rt unit or antenna coupler before tuning or transmitting to prevent damage to parts in the transmitter.

(1) Turn the TRANSMIT AUDIO control fully clockwise to TUNE; this action limits the transmitter power output to 25 watts.

(2) Preset the PA TUNE control to the operating frequency.

(3) Set the FUNCTION switch to CW.

(4) Plug the microphone or the handset into the HANDSET connector.

(5) Key the transmitter by pressing the microphone or handset push-to-talk switch.

(6) Adjust the PA TUNE control for a maximum indicated power output.

(7) If connected, tune the antenna coupler (fig. 3-3) (as described in (a) through (e) below) so that the reflected power is less than 5 percent of the forward power. Retuning is necessary if either the antenna or the operating frequency is changed. After tuning the antenna coupler, record the control settings to hasten future tuning to the same operating frequency.

(a) Set the controls initially as follows: COARSE TUNE to 1, FINE TUNE to 360, and LOAD to 900.

(b) Set the power meter switch to REFLECTED POWER.

(c) Key the rt unit transmitter.

(d) Rotate the LOAD control counterclockwise until the power meter displays a null indication. If a null indication is not obtained, return the LOAD control to 900 and advance the COARSE TUNE switch one position. Repeat the LOAD control tuning procedure until a null is accomplished.

(e) When a null indication is obtained, adjust the LOAD and FINE TUNE controls alternately to minimize reflected power.

(8) Release the microphone switch or hand key. Turn the TRANSMIT AUDIO control fully counterclockwise. While pressing the microphone switch or cw hand key, advance the TRANSMIT AUDIO control until a 25-watt output is indicated on the rt unit meter; then, repeak the PRESELECTOR control for a maximum deflection on the rt unit meter and tighten the control lock.

(9) Advance the TRANSMIT AUDIO control until the power output begins to level off; then, advance the TRANSMIT AUDIO control one dial division further.

NOTE

Do not rotate TRANSMIT AUDIO control beyond this setting, or distortion will result.

(10) Peak the PA TUNE control for a maximum power output.

(11) Readjust the antenna coupler FINE TUNE and LOAD controls to minimize reflected power.

c. Operating Procedures. After receiver and transmitter tuning procedures have been completed, select the desired mode of operation with the FUNCTION SWITCH. Operation of the radio set is the same in all modes. The rt unit is always in receive until the transmitter is keyed. Keying is accomplished with the push-to-talk switch on the handset or microphone, or automatically when the cw hand key is closed. In the cw mode, the handset or microphone is unplugged and the hand key connected.

3-8. Remote Control Operation

Remote audio and keying functions are provided by the remote control. Operate the radio set remotely as follows:

a. Tune and operate the radio set (paras 3-6 and 3-7).

b. Set the rt unit KEYLINE switch to LOCAL/REMOTE.

c. Connect the remote control to the rt unit through the interconnecting remote cable.

d. Connect the handset or the microphone to the front panel HANDSET connector on the remote control.

NOTE

If possible, both handsets or microphones connected to the rt unit and the remote control should be of the same type so that the rt unit TRANSMIT AUDIO control does not have to be readjusted when operation changes from local to remote.

e. Use the remote control function switch to select HANDSET, SPEAKER, or both (PARALLEL).

f. Adjust the remote control VOLUME control for a comfortable listening level. Audio and keying functions are now accomplished from both the radio set local and remote positions; however, remote keying is discontinued when the rt unit KEYLINE switch is set to LOCAL, or when the remote control VOLUME control is set to OFF.

3-9. Stopping Procedure

The radio set can be placed in standby operation

or completely shut down. If the radio set is shut down, the preliminary starting procedures (para 3-6), including warmup, must be followed to operate the equipment.

a. To place the radio set in standby, rotate the rt unit FUNCTION switch to STBY.

b. The radio set is shut down by setting the rt unit FUNCTION switch to OFF.

CHAPTER 5

ORGANIZATIONAL MAINTENANCE

Section I. MAINTENANCE

5-1. Scope of Organizational Maintenance

a. This chapter contains instructions covering organizational maintenance of the radio set and the remote control. Included are instructions for preventive and periodic maintenance services and repair functions to be performed by the organizational repairman.

b. Organizational maintenance of the radio set and the remote control includes—

- (1) Organizational preventive maintenance (paras 5-3, 5-4, and 5-5).
- (2) Lubrication (para 5-6).
- (3) Touchup painting (para 5-7).
- (4) Cable repair (para 5-8).
- (5) Troubleshooting (para 5-10).
- (6) Tests and adjustments (para 5-11).
- (7) Tube testing (para 5-12).

5-2. Tools, Materials, and Test Equipment Required

The replacement parts authorized for organizational maintenance are the running spares listed in appendix B. Tools required for organizational maintenance are contained in Toolkit, Electronic Equipment TK-101/G. The materials and test equipment are listed in *a* and *b* below.

a. Materials.

- (1) Cleaning compound (trichloroethane). Refer to appendix B for the Federal stock number.
- (2) Cleaning cloth.

b. Test Equipment. The only test equipment required for organizational maintenance is Multimeter AN/URM-105.

5-3. Organizational Preventive Maintenance

a. Organizational preventive maintenance is the systematic care, inspection, and servicing of equipment to maintain it in serviceable condition, prevent breakdowns, and assure maximum operational capability. Preventive maintenance is the responsibility of all categories of maintenance concerned with the equipment, and includes the inspection, testing, and repair or replacement of parts, subassemblies, or units that inspection and tests indicate would probably fail before the next scheduled periodic service. The preventive maintenance checks and services for the radio set and the remote control are made at monthly intervals, unless otherwise directed by the commanding officer.

b. Maintenance forms and records to be used and maintained on this equipment are specified in TM 38-750.

5-4. Monthly Maintenance

Perform the maintenance functions indicated in the monthly preventive maintenance checks and services chart (para 5-5) once each month. A month is defined as 30 calendar days of 8-hour-per-day operation. If the equipment is operated 16 hours a day, the monthly preventive maintenance checks and services should be performed at 15-day intervals. Adjustment of the maintenance interval must be made to compensate for any unusual operating conditions. Equipment maintained in a standby (ready for immediate operation) condition must have monthly preventive maintenance checks and services performed on it. Equipment in limited storage (requires service before operation) does not require monthly maintenance.

5-5. Organizational Monthly Preventive Maintenance Checks and Services Chart

Sequence No.	Item to be inspected	Procedure	Reference
1	Exterior.....	Remove all accumulated rust and corrosion; repair and finish.	Para 5-7.
2	Interconnecting and connectors.....	Check for cracks, breaks, cuts and wear; repair as required.	Para 5-8.
3	Antenna terminal.....	Check for good electrical and mechanical connection. If necessary, remove corrosion and tighten.	
4	Hardware.....	Remove covers and inspect chassis. Tighten or replace loose and missing hardware and remove accumulated dirt. Inspect seating of pluckout items, tubes, fuses, relays, and connectors.	Para 5-11a.
5	Publications.....	Check to see that all publications are complete, serviceable, and current.	DA Pam 310-4.
6	Modifications.....	Check DA Pam 310-7 for applicable MWO's. All new URGENT MWO's must be applied immediately. All MORMAL MWO's must be scheduled.	TM 38-750 and DA Pam 310-7.
7	Spare parts.....	Check for completeness of running spares.	App. B.
8	Lubrication.....	Lubricate equipment ¹	Para 5-6.
9	Pa. bias.....	Adjust pa. bias.....	Para 5-11c.
10	Operational test.....	Perform tests given in paragraph 5-11 after completing starting and operating procedures.	Paras 3-6 through 3-8 and 5-11.

¹ To reach the lubrication points, refer to paragraph 5-11a.

5-6. Lubrication

Lubricate the radio set during monthly preventive maintenance (para 5-5) at the locations shown in figures 5-1 through 5-4. Use grease, Aircraft (GAI) (FSN 9150-190-0883) for lubrication applications (do not overlubricate). During storage, lubrication is not necessary.

WARNING

HIGH VOLTAGES exist in an operating radio set. Make sure that power to the radio set is turned off before lubricating the radio set.

CAUTION

Lubricate required items only. Do not lubricate nylon bushings, switches, reduction drives, and the 1A9 assembly capacitor gear train and chain.

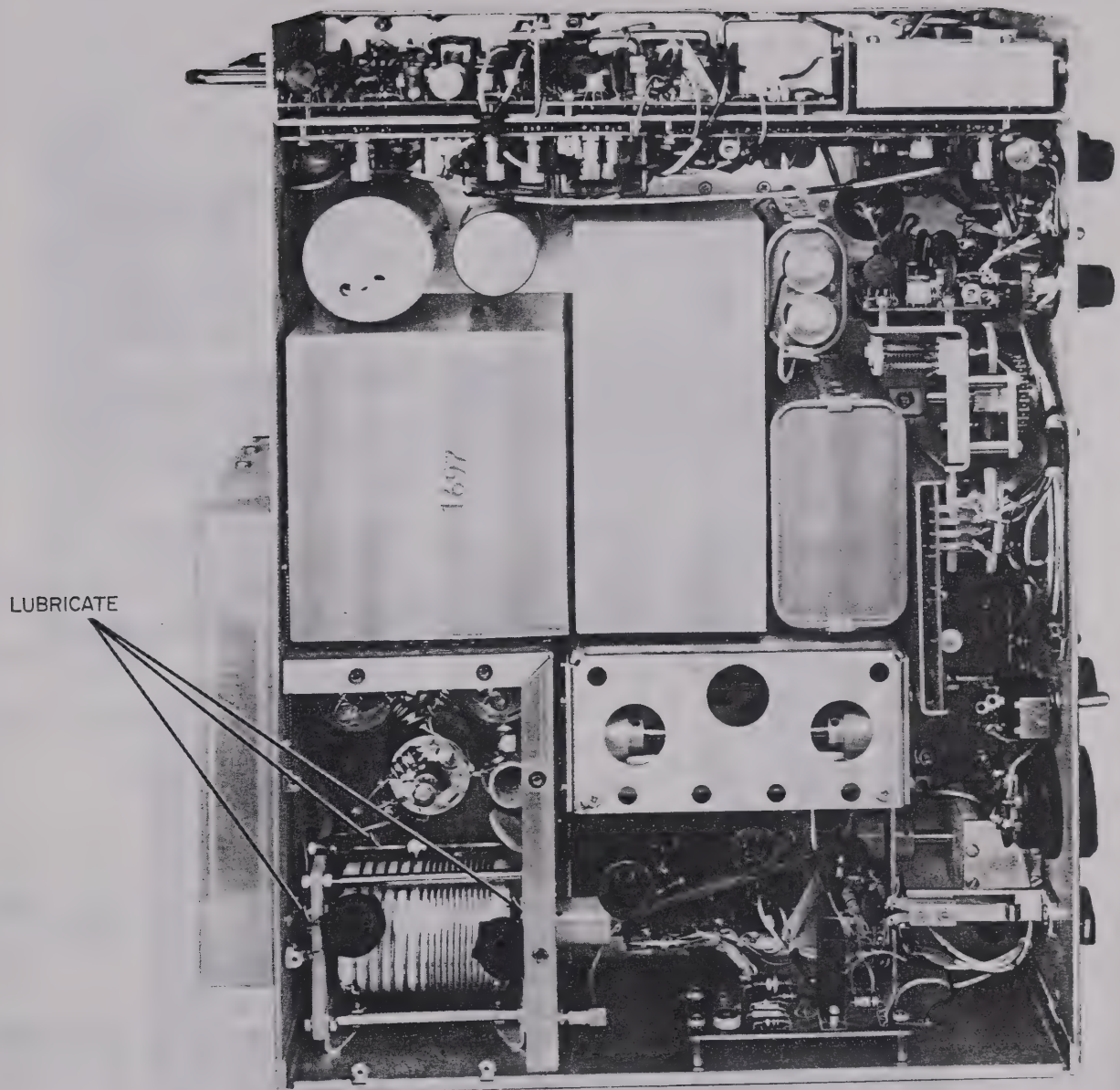
a. *Rt Unit* (figs. 5-1 and 5-2). In the rt unit, remove the cover (para 5-11a) and the pa. dust

cover (para 5-11a). Lubricate the pa. variable inductor shaft bearings and roller rod with a very light coating. Replace the pa. dust cover. Pull out the 1-kHz FREQUENCY KILOCYCLES control knob and *lightly* lubricate the exposed shaft. Replace the rt unit cover.

b. *Antenna Coupler* (figs. 5-3 and 5-4). In the antenna coupler, remove the cover (para 5-11a). Lubricate bearings indicated. Lightly lubricate the variable inductor roller rods, and the chain drive for L1 (fine tune inductor). Replace the antenna coupler cover.

5-7. Touchup Painting

Remove rust and corrosion from metal surfaces by lightly sanding them with fine sandpaper. Brush two thin coats of primer on the bare metal to protect it from further corrosion. Paint with a matching paint color and type. Refer to the applicable cleaning and refinishing practices specified in TB 746-10.



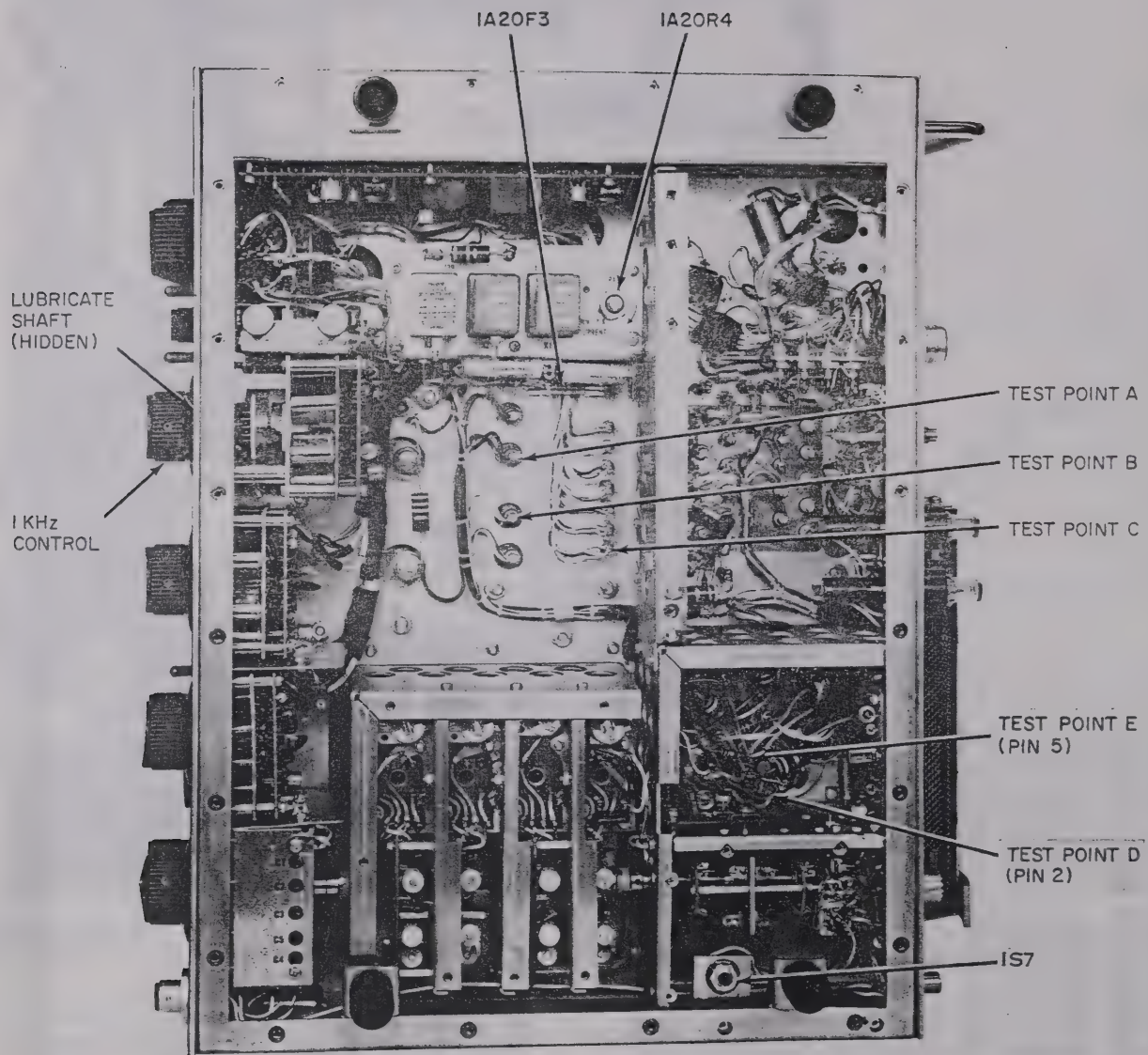
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Figure 5-1. Rt unit, top view, location of test lubrication points.

5-8. Cable Repair

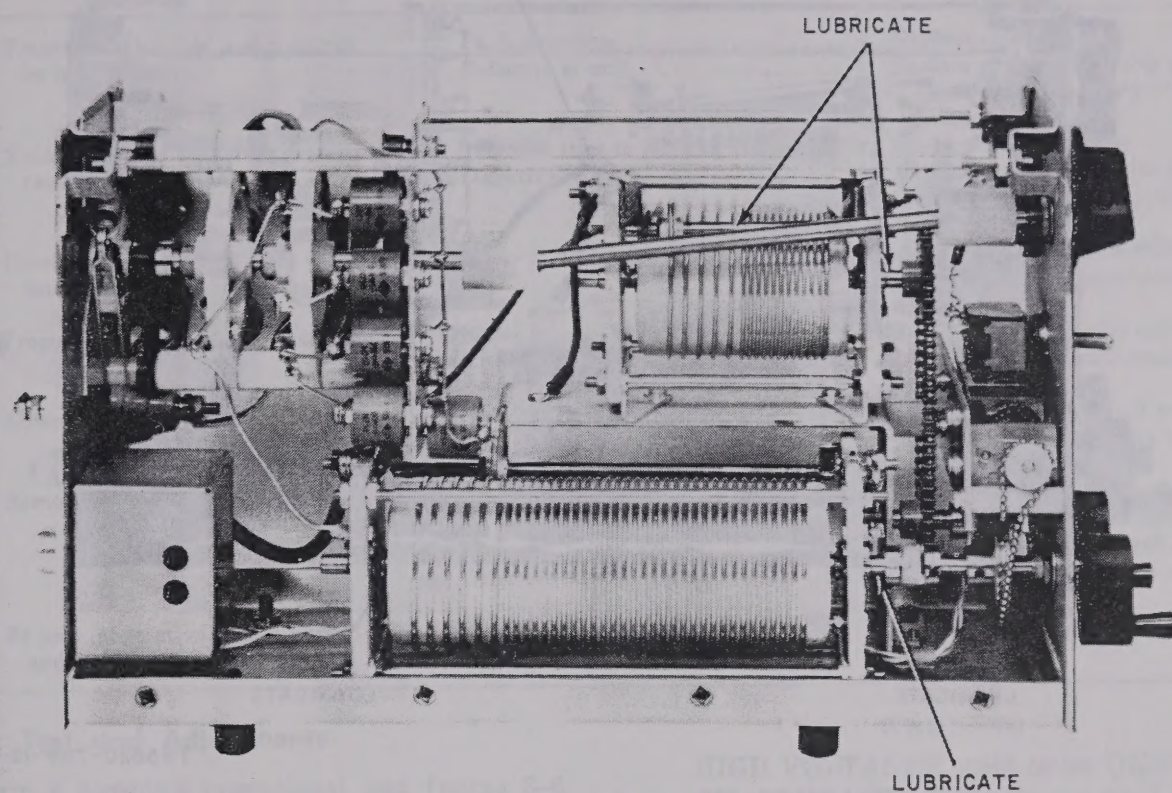
Perform temporary repairs to all wires and cables associated with the radio set. Tape all cuts, kinks, strains, or frays with electrical tape. Repair breaks by splicing. Splicing is accomplished by stripping and soldering color coded wires together

and wrapping each connection with tape. To splice a coaxial cable, solder the inner conductors together and insulate by wrapping with tape. Next, connect the outer braids with a short piece of wire. Lightly solder the braid to the wire, while avoiding excess heat, with a high capacity (100 watt, or larger) iron. Tape the entire splice.



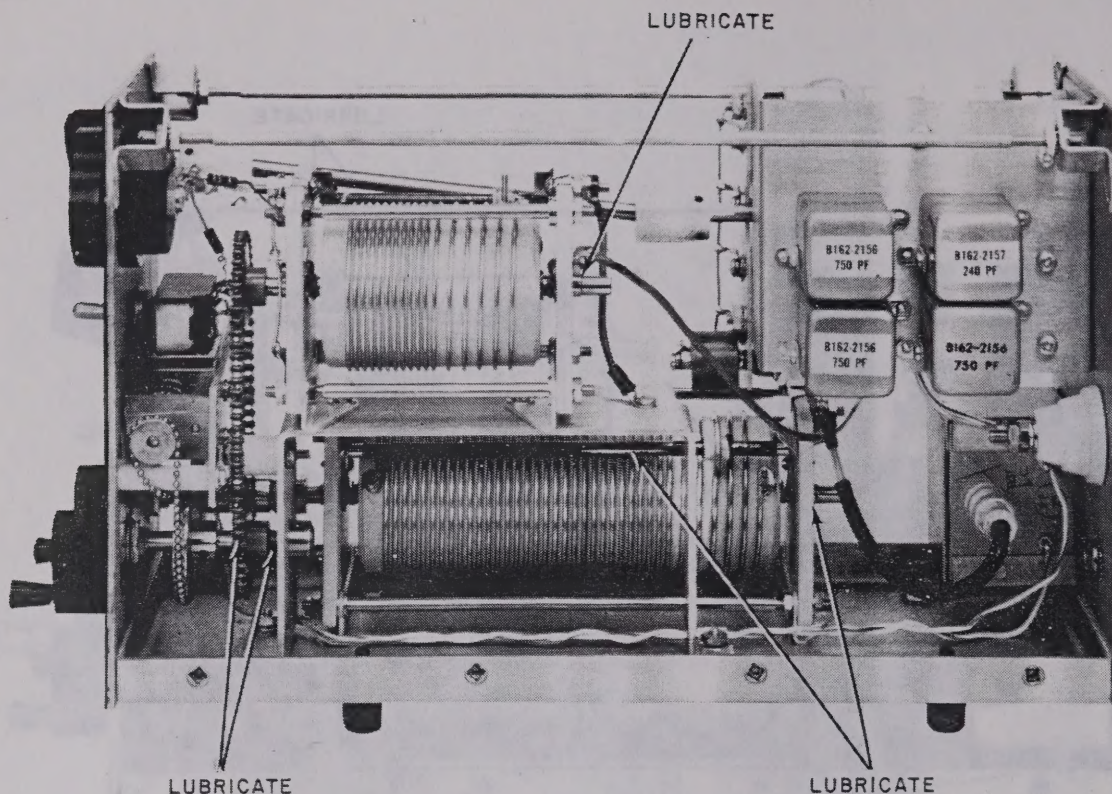
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Figure 5-2. Rt unit, bottom view, location of test and lubrication points.



TM 5820-759-12-C2-1

Figure 5-3. Antenna coupler, left side, location of lubrication points.



TM5820-759-12-C2-2

Figure 5-4. Antenna coupler, right side, location of lubrication points.

Section. II. TROUBLESHOOTING

5-9. General

Troubleshooting the radio set and the remote control is based on the functional checks contained in the monthly preventive maintenance checks and services chart. To troubleshoot the equipment, perform the procedures given in paragraph 5-5. When an abnormal condition or result occurs, perform the checks and corrective measures given in

the troubleshooting chart (para 5-10). Paragraph 5-12 gives tube checking instructions. If the corrective measures do not correct the trouble, higher category of maintenance is required. To remove the cover and to perform the equipment tests and adjustments used during troubleshooting procedures, refer to the instructions given in paragraph 5-11.

5-10. Organizational Troubleshooting Chart

Item No.	Trouble symptom	Probable trouble	Checks and corrective measures
1	Binding controls	Lack of lubrication	Lubricate unit (para 5-6). If trouble still exists, higher category of maintenance is required.
2	Rt unit tunes to spurious signals	PRESELECTOR control requires adjustment.	Adjust PRESELECTOR control (para 5-11d). If trouble still exists, higher category of maintenance is required.
3	Transmitter distortion, or short power amplifier tube life.	Pa. bias requires adjustment	Adjust pa. bias (para 5-11c).

Item No.	Trouble symptom	Probable trouble	Checks and corrective measures
4	Transmitter has low power output, or is inoperative.	a. Pa. is defective b. Defective rt unit	a. Replace defective tube. b. Replace rt unit. If trouble still exists, higher category of maintenance is required.
5	Transmitter has low power output; receiver lacks sensitivity.	a. Defective tube in RF amplifier b. Defective rt unit	a. Replace defective tube. b. Replace rt unit; if trouble still exists, higher category of maintenance is required.
6	Receiver has low sensitivity, or is inoperative.	Defective rt unit	Replace rt unit; if trouble still exists, higher category of maintenance is required.
7	Frequency is unstable, or incorrect	Defective rt unit	Replace rt unit; if trouble still exists, higher category of maintenance is required.
8	Antenna coupler is inoperative	Antenna coupler is defective	Replace antenna coupler; if trouble still exists, higher category of maintenance is required.
9	Remote control is inoperative	a. Remote control is defective b. Defective remote cable	a. Replace remote control; if trouble still exists, higher category of maintenance is required. b. Replace defective remote cable (para 5-8).
10	Rt unit inoperative. Meter lighted and rear panel fuses check good.	Fuse 1A20F3 blown	Replace defective fuse (fig. 5-2 and para 4-7).

5-11. Test and Adjustments

Perform a complete operational test (paras 3-6 and 3-7) and the pa. bias adjustment during the monthly preventive maintenance. While checking for malfunctions, operate the radio set in all modes. Compare the malfunction to the trouble-shooting chart. With a fully operational radio set and remote control, conduct the tests given in *b* below. Removal of the necessary equipment covers is described in *a* below.

WARNING

High voltages exist in the radio set. Make sure that the power source to the radio set is turned off before removing the covers. Operate the radio set without covers only to perform tests and adjustments (observe safety precautions).

a. Cover Removal.

(1) To reach into the rt unit, remove the 12 screws that hold the cover, and lift it off. Remove the 20 screws that secure the bottom cover and separate it from the rt unit. Remove the eight retaining screws from the pa. dust cover and remove the cover.

(2) To reach into the antenna coupler, remove the eight screws that hold the cover and separate the cover from the unit.

WARNING

HIGH VOLTAGES could cause DEATH ON CONTACT! Voltages up to 1,035 volts dc exist within the rt unit. Follow safe procedures when working near high voltages. Use a well-insulated test probe; hold fingers far back from exposed metal and, if available, wear insulated gloves.

b. Power Supply Voltage Measurements (fig. 5-2).

NOTE

Nominal power input voltages are 230 and 115 volts ac, and 13.5 and 26.0 volts dc, ± 10 percent. During tests and adjustments, provide power as close as possible to the nominal voltage requirements.

WARNING

Do not make voltage readings between test point A and ground. Voltages above 1,000 volts could be present. This measurement should be performed by higher category of maintenance personnel.

(1) Measure the +225 volts dc. Connect a positive test probe to test point B (fig. 5-2) and record the meter indication.

NOTE

Voltages between 192 and 258 volts are acceptable at test point B.

(2) Measure the +12 volts dc. Connect a positive test probe to test point C (fig. 5-2) and record the meter indication.

NOTE

Voltages between 10.2 and 13.8 volts are acceptable at test point C.

(3) Measure the ac ripple voltage on the +12-volt dc output. Use the AN/URM-105 set at a low voltage scale. Connect the test probe to test point C and record the meter indication.

NOTE

Ac voltage less than 10 millivolts is acceptable at test point C.

(4) Measure the 6.3 volts ac. Connect the test probe to test point D (fig. 5-2) and record the meter indication.

NOTE

Voltages between 5.36 and 7.24 volts are acceptable at test point D.

(5) Measure the -55 volts dc with the AN/URM-105. Connect the test probe to test point E (fig. 5-2) and record the meter indication.

NOTE

Voltages between -46.7 and -63.2 volts are acceptable at test point E.

c. Pa. Bias Adjustment.

NOTE

Adjust the pa. bias with the type (ac or dc) and voltage of primary power from which the radio set will normally be operated; otherwise, incorrect adjustment may result. However, for test purposes the adjustment should first be made in the test setup.

(1) Connect the dummy load to ANTENNA connector J4.

(2) Set the FUNCTION switch at either USB or LSB.

(3) Press and hold meter switch 1S7 (fig. 5-2).

(4) Do not speak into the microphone. Adjust pa. bias control 1A20R4 (fig. 5-2) for a meter indication of S9 on the front panel meter.

(5) Release the meter switch and remove the dummy load.

d. Control Knobs and Control Adjustments.

(1) Tighten all loose control knobs and make sure that the knobs do not rub against the panel.

(2) The PRESELECTOR control adjustment is accomplished by tuning the transmitter for a maximum power output at 8.8 MHz. Tune up from the low frequency end of the PRESELECTOR control until the rt unit meter indicates maximum power; then, loosen the PRESELECTOR control indicator ring setscrew. Set the indicator ring to 8.8 MHz and tighten the setscrew.

(3) Adjust the PA TUNE control by rotating it fully counterclockwise. Loosen both setscrews in the indicating ring under the control knob. Position the pointer to the reference mark on the front panel (a line slightly counterclockwise for the 2 MHz position) and tighten setscrews.

e. Tightening and Replacement of Hardware.

(1) Check the exterior of the equipment for loose or missing screws and nuts; replace and tighten where necessary.

(2) Check the security of the equipment to the shock mount.

5-12. Tube Testing

When trouble occurs, a tube can be at fault. If tube failure is suspected, remove and check the tube.

CAUTION

Do not rock or try to rotate a tube when removing it from a socket; pull it straight out. Rocking or attempting to rotate a tube can damage the tube socket and tube pins and result in complete failure or intermittent operation of the tube.

a. *Use of Tube Tester.* Remove and test one tube at a time. Discard a tube only if its defect is obvious, or if the tube tester shows it to be defective. Do not discard a tube that tests at, or near, its minimum test limit on the tube tester. Put back the original tube, or insert a new one if required before testing the next tube.

b. *Tube Substitution Method.* Replace a suspected tube with a known good tube. If the equipment remains inoperative, remove the replacement tube and put back the original tube. Repeat the procedure with each suspected tube until the defective tube is located, or it is determined that faulty operation is not caused by any of the tubes.